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5 Method for the production of a rim hole in hollow profiles

The invention relates to a method for the production of a rim hole in hollow profiles according to the preamble of patent claim 1.

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A method of the generic type has been disclosed by DE 43 22 632 A1. In this case, the hollow profile is used as a vehicle strut for the mounting of axles, wheel suspensions or the like and is shaped in a first
15 step by hydroforming into an outer contour corresponding to the loading requirements. Then, in a second step, centering holes are incorporated at the ends of the hollow profile, which are to have a mounting seat for accommodating rubber mounts, and a
20 spacer in the form of a tubular piece is inserted into the hollow profile centrally relative to said centering holes. Finally, a flow drill is inserted into the centering holes in the end region, this flow drill forming a rim hole during operation, and this rim hole
25 extending inside the tubular piece. In this case, the rim hole forms the mounting seat. However, a precondition of the flow drilling process is that there must be a certain ratio between the wall thickness of the hollow profile and the diameter, to be produced, of
30 the rim hole. That is to say that the wall thickness of the hollow profile is to be 'especially large in relation to the diameter. This usually cannot be maintained when applied in automobile construction, since the need to save weight leads to thinner and
35 thinner sheets. Furthermore, due to the process, the wall thickness of the rim hole decreases to virtually zero in the direction of application during the flow drilling. This has an adverse effect on the strength

and rigidity properties of the mount to be produced, despite the inserted tubular piece mentioned.

5 The object of the invention is to develop a method of the generic type to the effect that a rim hole in hollow profiles is made possible in a relatively simple manner, this rim hole complying with high strength requirements even in the case of a small wall thickness of the hollow profile.

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The object is achieved according to the invention by the features of patent claim 1.

Owing to the invention, in order to produce the rim
15 hole, it is merely necessary to punch out two opposite holes and bend over at least one of the hole edges, which are drawn into the hollow profile interior in the process and thus form the rough contour of the rim hole to be produced. In order to achieve the desired exact
20 contour of the rim hole, a tubular piece is inserted into the hollow profile interior and placed at the location of the rim hole to be produced, before the drawing-in from the open end of the hollow profile. In this case, the inside of the tubular piece serves at
25 least as a pattern for the desired contour of the rim hole, the hole edges being pressed against the inside of the tubular piece when they are being drawn in, as a result of which they achieve this same contour. Owing to the fact that the hole edges are not subjected to
30 any change in wall thickness when being bent over into the hollow profile interior, the tubular design of the rim hole, in addition to the already rigid tubular form per se, has especially high rigidity, which enables the rim hole, without sustaining damage, to cope with even
35 higher mechanical loads, for which sufficient rigidity and strength are indispensable. This is additionally promoted due to the fact that the tubular piece remains in the hollow profile. In contrast to the flow drilling, the ratio of diameter to length of the rim

hole is not limited to a specific value during the production of the rim hole, so that rim holes of virtually any desired dimensions can be advantageously formed. As a result of the uniformity of the wall thickness of the hollow profile, smaller wall thicknesses may also be selected when designing the hollow profile, while maintaining sufficient rigidity in the region of the rim hole. This contributes to the reduction in weight of the corresponding component and, when the component is used in the motor vehicle, to a reduction in weight of the latter. Furthermore, the method according to the invention has an advantageous effect for the painting of the component, i.e. of the hollow profile, since the surface of the rim hole is relatively regular and thus the paint can adhere to said surface. When steel is used for forming the hollow profile, there are advantageously no corrosion problems, as are brought about, for example, as a consequence of the flow drilling process.

In a preferred development of the invention as claimed in claim 2, the hollow profile is perforated by the interaction of a perforating die, pushed into the hollow profile, and two opposite perforating punches, between which the hollow profile lies. In a mechanically simple manner, this enables holes having a highly precise hole pattern to be formed and enables the hole edge to run uniformly, which ensures the uniformity of the subsequent drawing-in operation and is therefore beneficial to the process reliability of the production of the desired rim hole.

In a further, especially preferred development of the invention as claimed in claim 3, the hollow profile is formed by means of the internal high pressure forming process and is perforated in the internal high pressure forming tool required for this purpose. Here, too, a highly precise hole pattern is obtained, the holes being formed by perforating punches which act upon the

hollow profile with a cutting action against the internal high pressure which prevails in the hollow profile and which functions as supporting pressure suppressing subsidence or collapse. In an economical manner in terms of the method, the hollow profile is shaped in the same tool in accordance with the requirements, thereby resulting in a production plant which is extremely compact in terms of apparatus due to the integration of the perforating punches in the internal high pressure forming tool.

A further preferred configuration of the invention as claimed in claim 4 relates to the fact that the drawing-in operation is effected by means of a follow-on contour of the perforating punch, this follow-on contour adjoining a cutting edge formed on the end face of the perforating punch. Due to the arrangement of a follow-on contour on the perforating punch, the perforating and drawing-in operation is simplified and the production time for the rim hole is reduced, since the hollow profile has to be acted upon, at least from one side, merely by a perforating punch which is lowered further into the hollow profile interior in a simple manner, so that the follow-on contour of the perforating punch comes into contact with the hole edge and then uniformly bends the latter over and thus draws it into the hollow profile interior. The entire production apparatus for producing the rim hole is further simplified to a considerable extent by combining the functions of two tools, namely the drawing-in tool and the perforating tool, in the perforating punch.

The contents of claim 5 constitute a further preferred development of the invention. In this case, the hollow profile material of the hollow profile section is drawn into a recess of the tubular piece, this recess encircling in an annular manner and being open toward the end face of said tubular piece. On account of the

drawing-in in this way, part of the tubular piece forms a center section of the rim hole. This may be done to such an extent that, with a relatively small drawing-in length, the drawn-in hollow profile material serves
5 only to fasten the tubular piece, which fully maintains the function of the rim hole, for example as a bearing in an axle strut. The tubular piece in this case may be made of bronze or plastic, as a result of which it can additionally perform the function of a plain bearing.
10 No large wall thickness of the hollow profile is required in order to hold the tubular piece, as a result of which said wall thickness can be reduced to such an extent that the drawn-in hollow profile material if necessary produces low rigidity and
15 strength. These properties are alternatively provided by the tubular piece, which is relatively thick-walled. The tubular piece may also be made of a light alloy or of a steel material, as a result of which it can likewise be shaped by means of the internal high
20 pressure forming process.

In a further preferred configuration of the invention as claimed in claim 6, the hollow profile material is drawn in in such a way that it engages behind undercut
25 surfaces of the recess of the tubular piece. In this way, not only is a frictional connection achieved between the hollow profile and the pushed-in tubular piece, as is apparent in the directly preceding development of the invention as claimed in claim 5, but
30 positive locking is also achieved by the catching behind the undercut surfaces of the recess of the tubular piece, so that the tubular piece is held in the hollow profile in an especially reliable manner.

35 In a preferred development of the invention as claimed in claim 7, the hollow profile is perforated with holes of the same size being formed. As a result of holes of the same size being formed, uniform process control during the perforating and in particular during the

drawing-in is ensured. In addition, the control of the tools during the drawing-in operation is simplified, since the same amount of hollow profile material is bent over on both sides of the hollow profile, a factor
5 which produces a uniform drawing-in length and whereby the sequence of movements of the drawing-in tools is identical, so that the latter can be connected to a single control loop.

10 In a further preferred development of the method according to the invention as claimed in claim 8, the hollow profile is perforated with holes of different size being formed. Furthermore, the larger hole is dimensioned in such a way that its hole edge terminates
15 flush with the inside of the tubular piece. The hollow profile material is drawn in only on the side of the smaller hole, the hole diameter and the hollow profile section having the hollow profile material being dimensioned in such a way that said hollow profile
20 section extends across the entire length of the tubular piece after the drawing-in. In this way, firstly the production process is shortened, since hollow profile material only needs to be drawn in from one side, whereas only the hole is formed on the other side.
25 Secondly, from this one side on which the smaller hole is formed, so much hollow profile material is drawn in that the latter extends at least up to the edge of the larger hole on the other side of the hollow profile. In this case, firstly the tubular piece is reliably
30 enclosed and secondly a rim hole is formed which is completely gapless and level on account of its one-piece configuration. Thus, due to its freedom from discontinuities and its high surface quality, the rim hole is given especially high bending rigidity and
35 strength and also above average slidability properties, so that the rim hole is suitable in an especially effective manner for the use of plain bearings. This special configuration of the invention applies in particular to bushes of large diameter.

The invention is explained in more detail below with reference to several exemplary embodiments shown in the drawings, in which:

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fig. 1 shows a hollow profile section in preparation for a perforating operation of a method according to the invention, in a lateral longitudinal section,

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fig. 2 shows a lateral longitudinal section of the hollow profile, perforated in the meantime, from figure 1 in preparation for a drawing-in operation of a method according to the invention,

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fig. 3 shows a hollow profile section drawn in on both sides with formed rim hole, in a lateral longitudinal section,

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fig. 4 shows a perforated hollow profile section drawn in on one side with fully formed rim hole of a method according to the invention, in a lateral longitudinal sectional illustration,

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fig. 5 shows a perforated hollow profile section drawn in on both sides, with hole edges drawn into a recess of a tubular piece arranged in the hollow profile, with a rim hole of a method according to the invention being formed, in a lateral longitudinal sectional illustration,

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fig. 6 shows a hollow profile section perforated and drawn in at the hole edges according to the invention, in a positive-locking connection with a tubular piece arranged in the hollow profile, in a lateral longitudinal section.

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Shown in figure 1 is the first working phase of the production of a rim hole on a hollow profile 1 which is made of a steel material or a light alloy and can be shaped by means of an internal high pressure forming process. The hollow profile produced in this way can preferably be a strut with bearing bush in automobile construction, in particular a tension or compression strut in the chassis region. For the first phase of the production process, in which a perforating operation is carried out on the hollow profile 1, a perforating die 3 is pushed into the open end 2 of the hollow profile 1 and arranged at the location of the rim hole to be produced. To this end, the perforating die 3 has a through-hole 4 of cylindrical design. Lying opposite the openings 5 of the through-hole 4 are the end faces 6 of two perforating punches 7 which are arranged outside the hollow profile 1. In their shape and in their diameter, the end faces 6, provided with a cutting edge 19, of the perforating punches 7 are dimensioned in such a way that, during the perforating of the hollow profile 1, they can plunge with only slight clearance into the through-hole 4 of the perforating die 3. After the two perforating punches 7, which are opposite one another and between which the hollow profile 1 lies, have completed the perforating operation, the perforating die 3 is removed again from the end 2 of the hollow profile 1. As can be seen from figure 2, the hollow profile 1 is then transferred with its two opposite, punched-out holes 8 into a drawing-in station. A cylindrical sleeve-shaped tubular piece 9 is now pushed into the hollow profile end 2 and is placed in the hollow profile 1 in such a way that it coaxially surrounds the location of the rim hole 20 to be produced, the axis 10 of the tubular piece 9 being identical to the hole axis of the two holes 8. The tubular piece 9, which can be made, for example, of plastic, steel or a light alloy, possibly also of bronze, has an inside diameter which markedly exceeds the hole diameter. The resulting hollow profile section

18 covering the openings 11 of the tubular piece 9 and lying between the hole edges 12 and the inside 16 of the tubular piece 9 forms the hollow profile material to be drawn in for producing a rim hole 20. Two drawing-in punches 13 which are arranged in such a way that they can be guided in a reciprocating manner coaxially to the axis 10 of the tubular piece then act from outside on the perforated hollow profile 1. With a cylindrical, short extension 14 which lies centrally and is formed on the respective drawing-in punch 13 for centering purposes, the drawing-in punches 13 plunge into the respective hole 8, after which, during the further movement of the drawing-in punches 13 into the hollow profile interior 17, the hollow profile section 18, by means of a concave drawing-in contour 15, adjoining the extension 14 at the rear side, of the punch 13, is displaced until it bears flat against the inside 16 of the tubular piece 9 and is pressed in place there. Firstly, the hollow profile material, thus drawn into the hollow profile interior 17, of the hollow profile section 18 fixes the tubular piece 9 in a rattleproof manner in the hollow profile 1 by means of the friction grip, produced via the applied pressure, between the inside 16 of the tubular piece 9 and the hollow profile section 18. Secondly, the drawn-in hollow profile section 18 forms the desired rim hole 20.

The drawing-in contour 15 of the drawing-in punch 13 may also be formed by a follow-on contour, adjoining the cutting edge 19, of the perforating punch 7. In this case, however, it is necessary in the sequence of the production operation to withdraw the perforating punch 7 slightly after the perforating, so that the tubular piece 9 can be pushed into the hollow profile end 2 and be placed accordingly. The perforating punch 7 then travels into the hole 8 and draws in the hollow profile material of the hollow profile section 18 as before. It may be noted here that the hollow profile

material is supported on the tubular piece 9 during the drawing-in operation, so that the hollow profile 1 cannot collapse. After completion of the drawing-in operation, the punches 13 or 7 are removed from the hollow profile 1. The tubular piece 9, which has produced the supporting effect and is now held by the rim hole 20 produced, remains permanently in the hollow profile 1. Due to the fact that it is in one piece with the hollow profile 1, the rim hole 20 produced also has especially high strength and rigidity relative to mechanical loads. In this respect, it is advantageous that, during the perforating, the hole size of the holes 8 produced is configured in such a way that that proportion of the hollow profile material of the hollow profile section 18 that can be drawn in, in the surrounding area of these holes 8, jointly corresponds at most to the mountable length of the tubular piece 9, since otherwise, when the hollow profile 1 is drawn in on both sides, the hollow profile sections 18 will overlap on both sides in the hollow profile interior 17, a factor which drastically restricts the possible use of the formed rim hole 20 or possibly does not allow it to be used in a chassis strut. In the event of the drawing-in being effected on one side, the drawn-in hollow profile material would protrude on the other side of the tubular piece 9, a factor which is likewise not desirable in many applications.

The rim hole 20 which can be seen from figure 3 is created in such a way that the hollow profile sections 18 drawn in on both sides come to lie with their terminating edges 21 approximately centrally relative to the tubular piece 9. Said rim hole 20 is the result of the method steps from figures 1 and 2, the hollow profile 1 having been perforated in such a way that opposite holes 8 of the same size have been created on both sides. Although the punching of holes 8 of different size is conceivable, during which the terminating edges 21 of the hollow profile sections 18

then come to lie eccentrically when the hollow profile material is drawn in, the forming of holes 8 of the same size is advantageous in the sense that the perforating die 3 can be of relatively simple design, since its through-hole 4 can simply be designed to be cylindrical without widening of the hole 4 being necessary.

A variant of the rim hole 20 can be seen from figure 4. In deviation from its previous design, the hollow profile 1 is perforated on one side in such a way that the hole edge 22 terminates flush with the inside 16 of the tubular piece 9. In contrast, on the opposite side of the hollow profile 1, a hole 8 is produced which is considerably smaller in its dimensions. From this side, the hollow profile material of the hollow profile section 23 located between the hole edge of the small hole and the inside 16 of the tubular piece 9 is now drawn into the hollow profile interior 24. Since the diameter of the larger hole 25 corresponds to the inside diameter of the tubular piece 9 and the length of the drawn-in hollow profile section 23 corresponds to the sum of the length of the tubular piece 9 and twice the wall thickness of the hollow profile 1, a rim hole 26 is produced which extends across the entire length of the tubular piece 9, as a result of which the latter is completely enclosed on the inside 16.

A further variant of the invention is shown in figure 5. In deviation from the preceding exemplary embodiments, the tubular piece 9 has a recess 27 which encircles in an annular manner and is open toward the end face 28 of the tubular piece 9. During the perforating operation, a relatively large hole 8 is punched out on both sides in the process, so that only a small amount of hollow profile material can be drawn in during the drawing-in operation. The length of the corresponding hollow profile section 29 is in this case dimensioned in such a way that the hollow profile

material is merely drawn into the recess 27 of the tubular piece 9 and pressed in place there. The resulting rim hole 30 is formed essentially by that section 31 of the inside 16 of the tubular piece 9
5 which is left without a recess.

A variant of the type of rim hole 30 from the preceding exemplary embodiment can be seen from figure 6. Here, the recess 27 also has an annular groove 32, the flanks
10 of which form undercut surfaces 33. When the hollow profile material of the hollow profile section 29 is drawn in, the hollow profile material engages behind these undercut surfaces 33, as a result of which a positive-locking connection between the tubular piece 9
15 and the hollow profile 1 is formed. In its shape, the rim hole 34 created in the process differs only slightly from the rim hole 30.